

# LDPC Decoder using Low Complexity Min Sum Algorithm with QPSK Modulation

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**Abstract—** In communication system signal is transmitted and received at the output. But due to various external noise errors occur in the received data in comparison to the transmitted one. To eliminate the errors various error correction techniques are used. LDPC decoder is one such technique. It is the recent technique that is used and it has better performance than the other error correcting techniques in terms of power, reliability and performance. Existing construction method is limited in some way in producing good error correcting performance and easily implementable codes for a given rate and length. In this paper LDPC codes are implemented using Min sum algorithm with reduced complexity than the existing methods. Moreover the existing methods use BPSK modulation but in this paper QPSK modulation is used to improve the BER. The main aim of this paper is to improve the Bit Error Rate in comparison to the other existing methods with less number of iterations and thus improving the performance and the flexibility is improved by varying the code size by increasing or decreasing the sub matrix size.

**Index Terms—**BER(Bit error rate), Min-sum algorithm, QPSK(Quadrature phase shift keying), Reduced complexity.

## I.INTRODUCTION

Communication involves transmission of the data through the encoder where redundant bits are added and then transmitted through the channel and in the decoder the redundant bits are removed and the original information is obtained. According to the Shannon's coding theorem, the data rate should be less than the channel capacity. But this is not possible under all circumstances. In between in the channel error may occur due to external noise. This external noise were corrected by retransmission in earlier methods. But retransmission causes delay in time cost and system throughput. So forward error correction techniques were adopted and LDPC code is one such technique. LDPC codes are block codes. For this various decoding algorithms were introduced but recently min sum algorithm is the most efficient method. But various iterative techniques are involved. Earlier 50 to 60 iterations were done and due to advancements 25 iterations were used but now in the recent days expected result is obtained in 6 to 7 iterations. These high efficient decoders are used in one way

communication such as deep space communication, satellite communication, wireless communication and magnetic storage in hard disk drives. Additionally nowadays these decoders are used in satellite television, optical networking. Digital video broadcasting also uses LDPC decoders.

## II. EXISTING METHOD

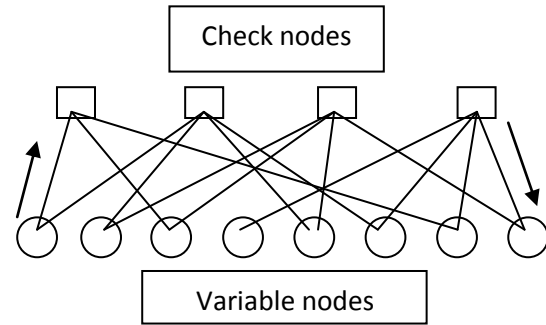
In 1950's hamming codes were adopted, later in 1960's BCH codes were introduced moreover LDPC codes were introduced in 1960's but was not popularized. Then Reed Solomon codes were introduced and used but it had many disadvantages. Then convolutional codes came into picture. Further till 1990's various practical implementation codes were introduced. Later turbo codes were introduced then LDPC codes were renewed and now it beats all the other codes including the turbo codes due to its various advantages like less complexity, more accurate, more error correcting performance with less power[2]. This is the first code that is very close to the Shannon's limit. Earlier first belief propagation was introduced but due to its limitations that it is complex for hardware implementation. Belief propagation cannot solve the graphical models that has cycles[3]. Moreover in sum product algorithm there are various computational complexity and it has less memory, requires more quantization when using LLRs[5]. Message passing algorithm offers no convergence guarantees, and no quality of the final decision[4]. Then bit flipping algorithm has poor performance than min sum algorithm. The iteration count will be more in bit flipping[6]. Then min sum was introduced now various min sum algorithm has been adopted like normalized, offset, optimized[1]. But in the previous papers BPSK modulation[1] is used and the BER is found to be less than the proposed paper.

## III.PROPOSED METHOD

LDPC decoder is a linear error correcting code. Unlike the other codes it has memory. When memory is present the noise parameter can be reduced. In comparison to the other methods, it has reduced complexity, high throughput, better performance and better SNR in comparison to other

methods. Recently, LDPC codes have received a lot of attention because their error performance is very close to the Shannon limit when decoded using iterative methods. They have emerged as a viable option for forward error correction (FEC) systems and have been adopted by many advanced standards, such as 10 Gigabit Ethernet(10GBASET) and digital video broadcasting (DVB-S2). Also the next generations of WiFi and WiMAX are considering LDPC codes as part of their error correction systems. The algorithm used is Min sum algorithm. Min sum messages are in log likelihood ratio. Min sum algorithm is more robust to quantization errors. It requires simpler hardware for check node. The LLR messages are passed from check nodes to variable nodes and from variable node to check node. It has less complexity and degradation in performance is small compared to other algorithms. In min sum the channel state information need not be known. They are subject to lower error floor even with uniform and finite quantization bits. It also has high SNR.

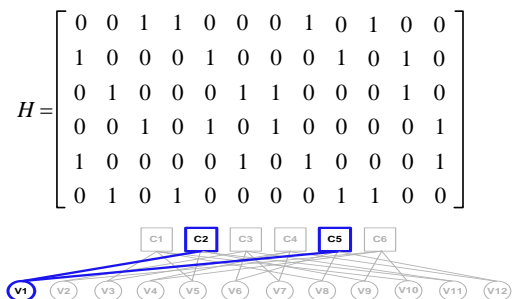
In the present paper, the previously Split Row method for decoding regular Low-Density Parity-Check (LDPC) codes, is extended to irregular LDPC codes; a reduced complexity decoding method which splits each row module into two nearly-independent simplified portions, moreover the modulation used is BPSK in the previous papers, in this paper we use QPSK modulation. This method reduces the wire interconnect complexity between row and column processors and increases parallelism in the row processing stage. The Split-Row method also simplifies row processors which results in an overall smaller decoder; Defined as the null space of a very sparse  $M \times N$  parity check matrix  $H$ , an LDPC code is typically represented by a bipartite graph, called Tanner graph, in which one set of  $N$  variable nodes corresponds to the set of code word, another set of  $M$  check nodes corresponds to the set of parity check constraints and each edge corresponds to a non-zero entry in the parity check matrix  $H$ . An LDPC code is known as  $(j,k)$  regular LDPC code if each column and each row in its parity check matrix have  $j$  and  $k$  non-zero entries, respectively. The construction of LDPC code is typically random. As illustrated in Figure 1, LDPC code is decoded by the iterative belief propagation(BP) algorithm that directly matches its Tanner graph.



**Figure 1:** Tanner graph representation of a LDPC code and the decoding message flow

#### IV.TANNER GRAPH

LDPC codes are defined by an  $M \times N$  binary matrix called the parity check matrix  $H$ . The number of columns represented by  $N$  defines the code length. The number of rows in  $H$ , represented by  $M$ , defines the number of parity check equations for the code. Column weight  $W_c$  is the number of ones per column and row weight  $W_r$  is the number of ones per row. LDPC codes can also be described by a bipartite graph or Tanner graph. The parity check matrix and corresponding Tanner graph of an LDPC code with code length  $N=12$  bits are shown in Figure 2. Each check node  $C_i$  corresponding to row  $i$  in  $H$  is connected to variable node  $V_j$  corresponding to column  $j$  in  $H$ . LDPC codes can be iteratively decoded in different ways depending on the complexity and error performance requirements. Sum-Product(SP) is near-optimum decoding algorithms which are widely used in LDPC decoders and is known as standard decoders. This algorithm perform row and column operations iteratively using two types of messages: check node message  $\alpha$  and variable node message  $\beta$ . The parity check matrix and the block diagram of the standard decoding algorithm are shown in Figure 3 respectively.



**Figure 2:** Parity check matrix and Tanner graph representation of an irregular LDPC code with code length  $N = 12$  bits. Check node  $C_i$  represents a parity check constraint in row  $i$  and variable node  $V_j$  represents bit  $j$  in the code

The entire H matrix, for an irregular LDPC code is composed of two sub matrix; the systematic sub matrix  $H_s$  and the parity one  $H_p$ , shown in Figure 3. The sub matrix  $H_p$  is that adopted by WiMax Mobile. LDPC codes are commonly decoded by an iterative message passing algorithm which consists of two sequential operations.

The row processing or check node update and column processing or variable node update. In row processing, all check nodes receive messages from neighbouring variable nodes, perform parity check operations and send the results back to neighbouring variable nodes. The variable nodes update. In row processing, all check nodes receive messages from neighbouring variable nodes, perform parity check operations and send the results back to neighbouring variable nodes. The variable nodes update soft information associated with the decoded bits using information from check nodes, and then send the updates back to the check nodes, and this process continues iteratively.

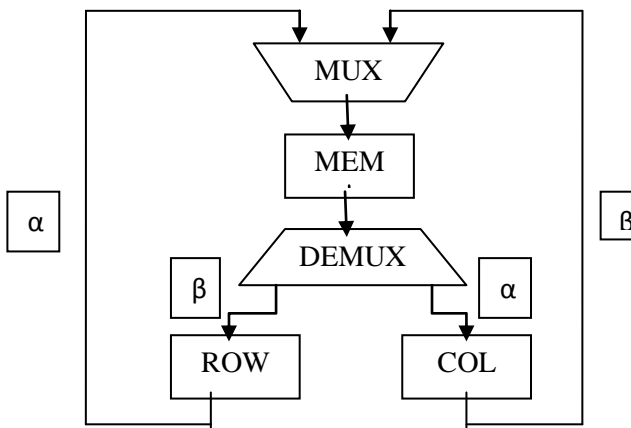


Figure 3: Block diagram of a typical standard decoder

## V. PROCEDURE

The layer decoder algorithm is proposed in this paper and processed for decoding in LDPC codes for parity check. The input matrix  $H=M \times N$  is chosen and is transposed. Encoding is done for the transposed matrix and transmitted through a channel. The output is decoded using proposed algorithm, layer decoder and is checked with the input to reduce the error which increases the performance. The block diagram of the proposed method is shown in figure. First the input H matrix is defined separately in coding. This input H matrix is then taken transpose so that it can be used in the implementation. Then the encoding process is done. The modulation used here is the QPSK modulation. Then when it is transmitted in the AWGN is added to it. The redundant bits added also will help in the reduction of the BER. Then in

the decoding part the transmitted bit is decoded and the input is obtained with less BER.

## VI. BLOCK DIAGRAM

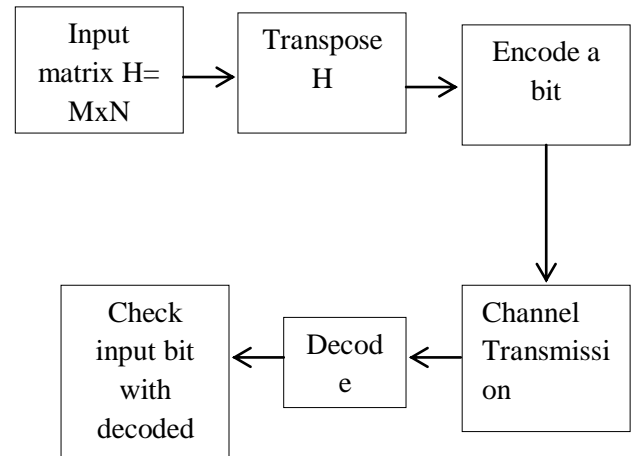


Figure 3.1: Block Diagram of Proposed Method

## VI. SIMULATION RESULT

Matlab is used for finding the BER, FER and SNR. Various built in commands are used here. The decoding of LDPC code is processed using Min-Sum algorithm with Gaussian noise and without Gaussian noise is shown in Figure 4.1 and 4.2 which calculates the Bit Error Rate (BER).

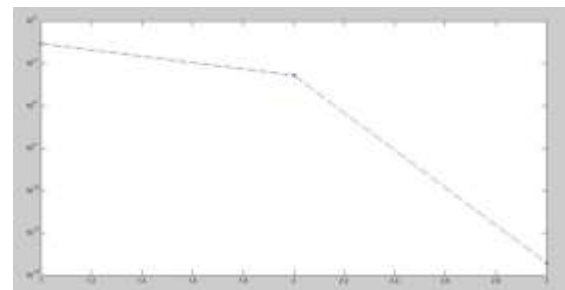


Figure 4.1: Bit Error Rate calculations with Gaussian noise

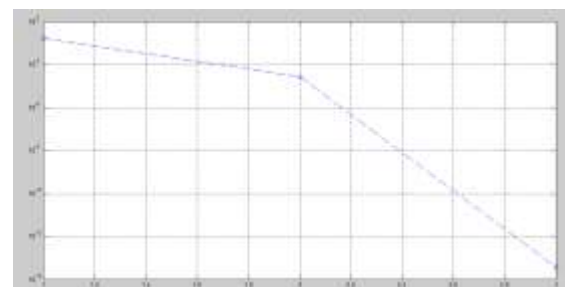
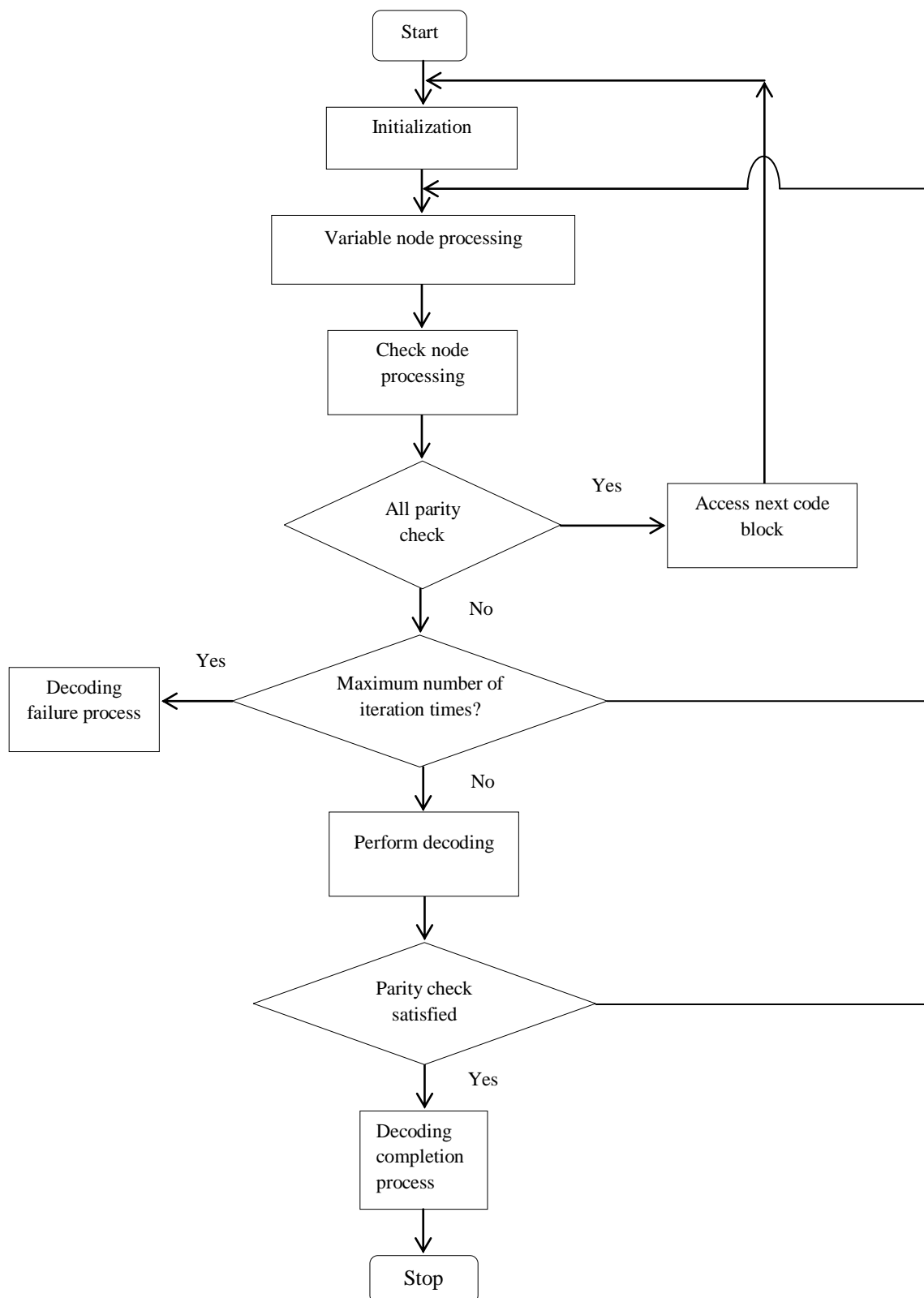


Figure 4.2: Bit Error Rate calculations without Gaussian noise

## VII.FLOW CHART



ALGORITHM	BER
SUM PRODUCT	$10^{-1} - 10^{-4}$
1.NORMALISED MIN SUM 2.OFFSET MIN SUM	$10^{-3} - 10^{-6}$ $10^{-3} - 10^{-6}$
QUANTIZED MIN SUM 1.IDEAL 2.CLIPPED 3.IDEAL	$10^{-2} - 10^{-7}$ $10^{-2} - 10^{-6}$ $10^{-2} - 10^{-8}$
MIN SUM BPSK	$10^{-2} - 10^{-12}$
SINGLE MIN SUM BPSK	$10^{-4} - 10^{-15}$
SINGLE MIN SUM QPSK	$10^{-4} - 10^{-14}$

**TABLE 1:** Comparison of BER of the proposed model with the existing models

From the figure 4.1 and 4.2 it shows that the percentage of BER for LDPC code with Gaussian noise gradually decreases from  $10^{-4}$  to  $10^{-14}$

### VIII. CONCLUSION AND FUTURE ADVANCES

From the table it can be noted that the Bit Error Rate has been greatly reduced compared to the other existing methods. Moreover the modulation technique used in the previous is BPSK but in the proposed model QPSK is used. Hence this LDPC decoder is used in most applications in communication nowadays. Wifi and Wimax technology uses LDPC decoders. They are more efficient than turbo codes, which is considered as the recent development. LDPC decoders are used in satellite communication such as Digital video broadcasting. In this paper the irregular input matrix is decoded using the min sum algorithm with reduced complexity which proves it to be the

more efficient method for error detecting and correcting methods. In the mere future this can be further developed by giving constant input and obtaining the output in the minimum number of iterations.

### IX. REFERENCES

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